Measurement Setups for Millimeter-Wave Antennas at 60/140/270 GHz Bands

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Outline

- Introduction
- Measurement Setups for Millimeter-Wave Antennas
  - ✓System considerations
  - ✓60-GHz system
  - ✓140-GHz system
  - ✓ 270-GHz system
- Conclusions

Existing and emerging mmW/sub-mmW applications

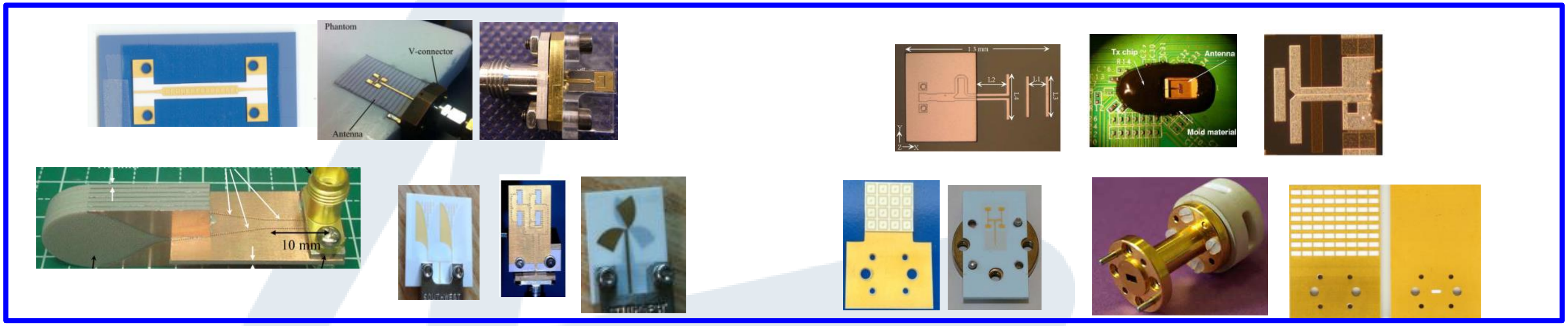
Frequency (GHz)	Applications
57-66	WiGig unlicensed band w/2.5 Gbps 802.15,802.11ad Wireless HD
60	Wireless backhaul w/100-300Mbps
71-76	Point-to-point licensed communication links w/1.25 Gbps-10Gbps (planned)
77	Automotive Radar
81-86	Point-to-point licensed communication links w/1.25 Gbps-10Gbps (planned)
92-95	Point-to-point licensed communication links w/1.25 Gbps-10Gbps (planned)
94	100MHz band reserved for space-borne radios Imaging radar Airport ground control Cloud profiling radar
110-500	Materials imaging
120-124 138-144	Local networking
122	Automotive Radar
180-210	Atmospheric satellite monitoring
180-300	Security & healthcare
225-750	Experimental radar
300-1000	Radio astronomy

Millimeter Wave Market worth $1.2 Billion – 2018

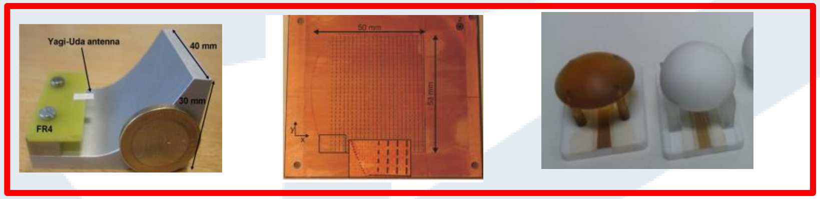
Research and Markets

Reported mmW/sub-mmW antennas

60 GHz antenna

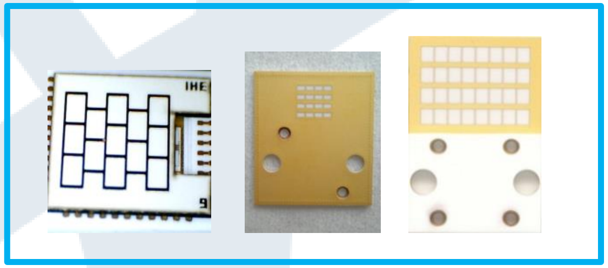

Phantom
V-connector
Antenna
10 mm
1.3 mm
L2
L1
L4
L3
Tx chip
Antenna
Mold material

77 GHz antenna


Yagi-Uda antenna
40 mm
30 mm
FR4
50 mm

100 GHz antenna

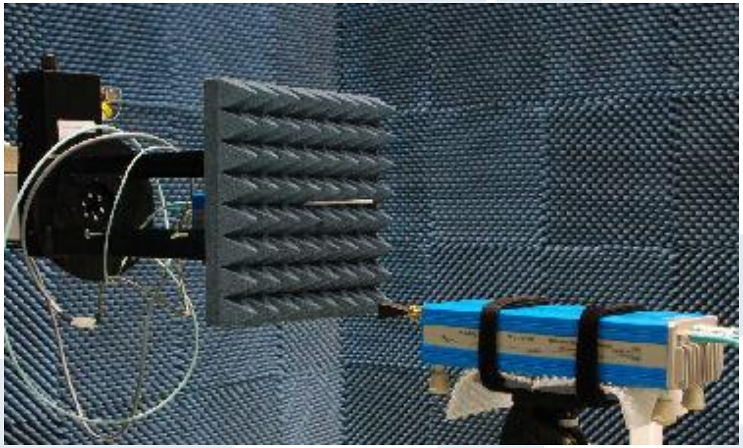
140 GHz antenna

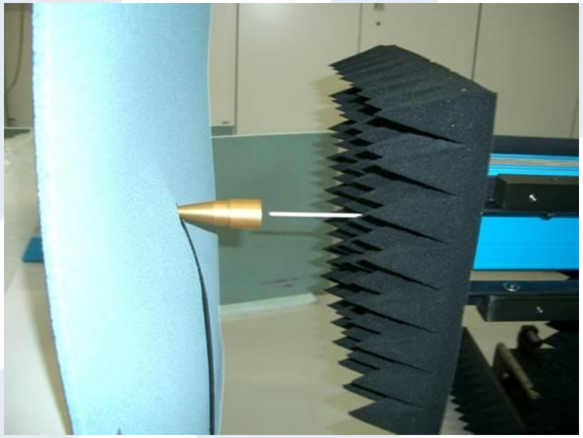


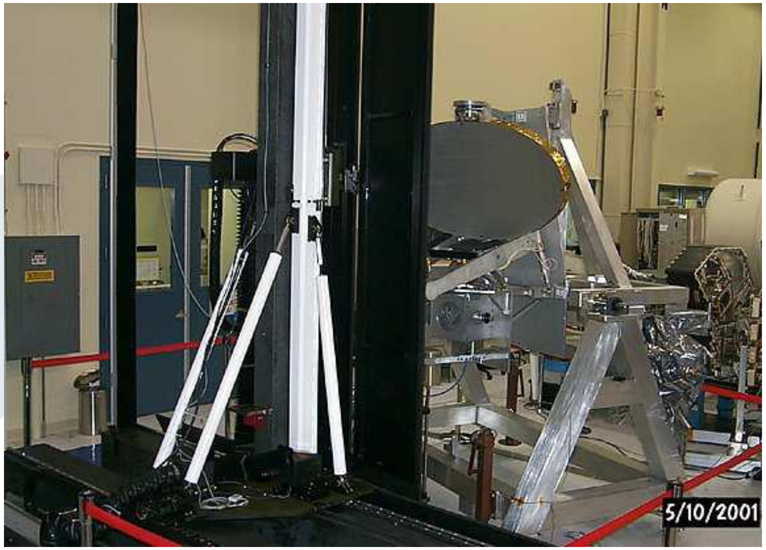
270 GHz antenna

MmW/sub-mmW antenna measurement set-ups

Near-field system





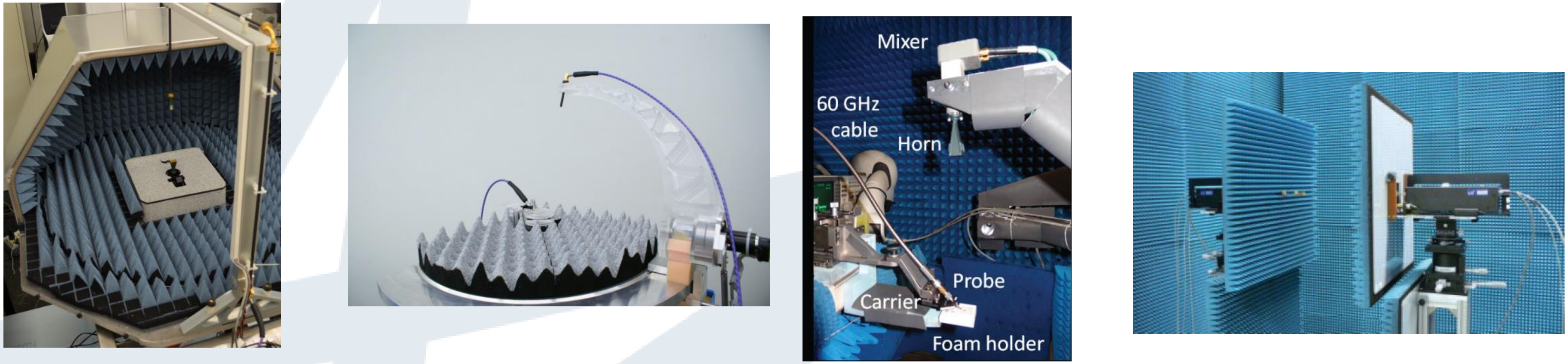


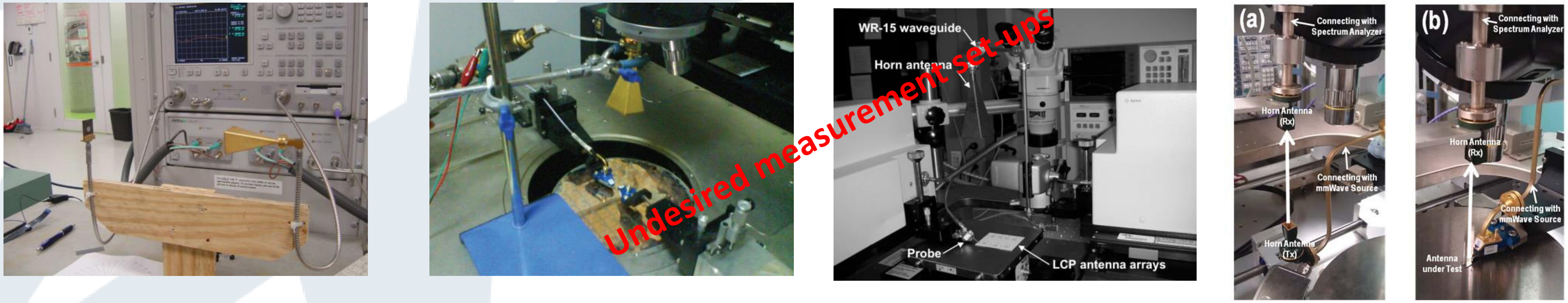
NSI, sub-millimeter wave (@550GHz)
planar near-field scanner in support of the
NASA Sub Millimeter Wave Astronomy Satellite

- **Expensive**
- **Suitable for coaxial/waveguide fed antenna**

Reported mmW/sub-mmW antenna measurement set-ups

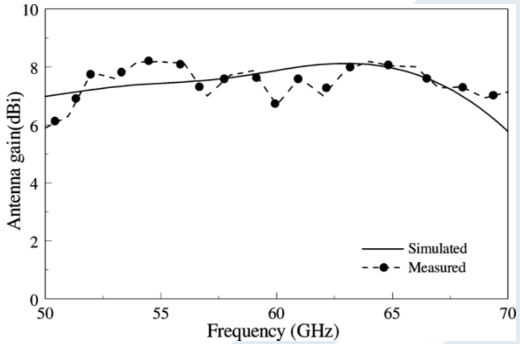
Far-field systems

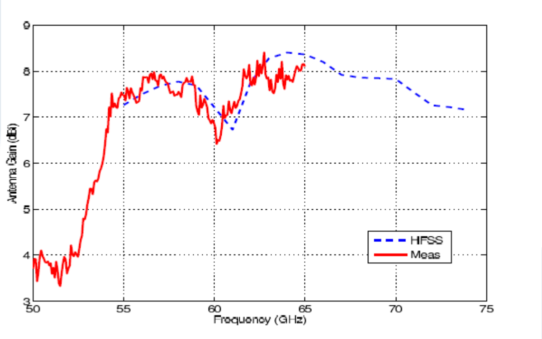

Mixer
60 GHz cable
Horn
Probe
Carrier
Foam holder

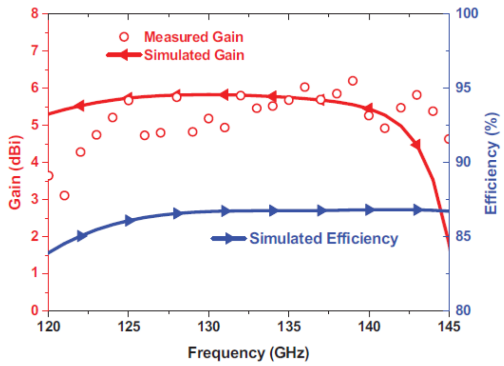

Undesired measurement set-ups
WR-15 waveguide
Horn antenna
Probe
LCP antenna arrays
(a)
Connecting with Spectrum Analyzer
Horn Antenna (Rx)
Connecting with mmWave Source
Horn Antenna (Tx)
(b)
Connecting with Spectrum Analyzer
Horn Antenna (Rx)
Connecting with mmWave Source
Antenna under Test

Undesired measurement results

Gain

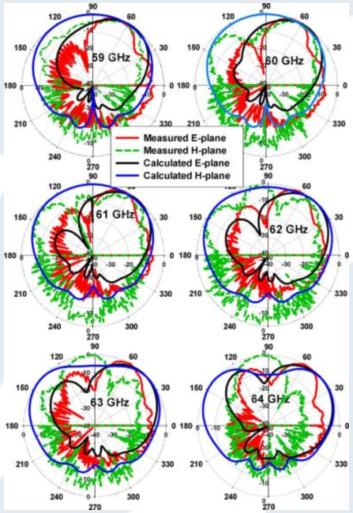


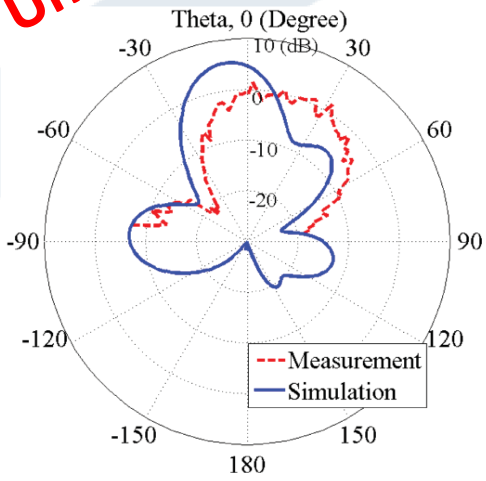


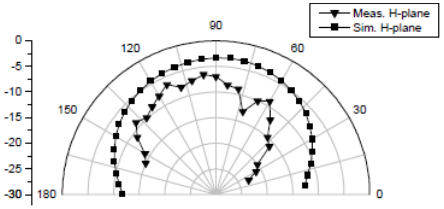


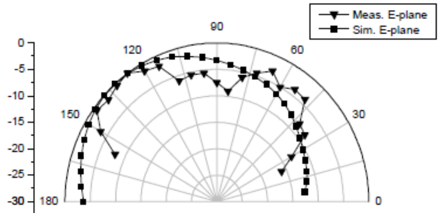
Radiation pattern

Undesired results









Outline

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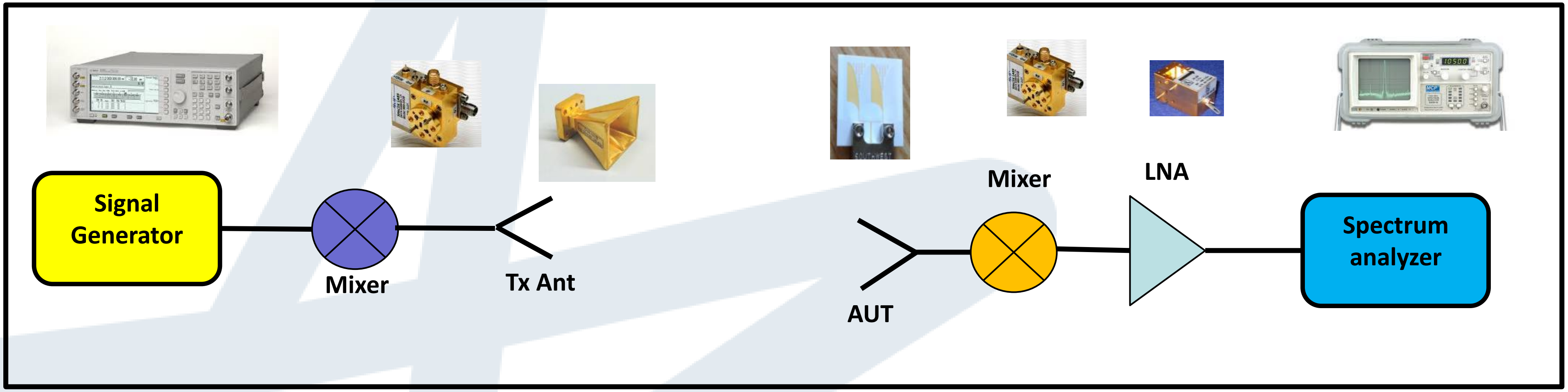
- ➢ **Measurement Setups for Millimeter-Wave Antennas**
  - ✓ System considerations
  - ✓ 60-GHz system
  - ✓ 140-GHz system
  - ✓ 270-GHz system
- ➢ Conclusions

Considerations for system configuration

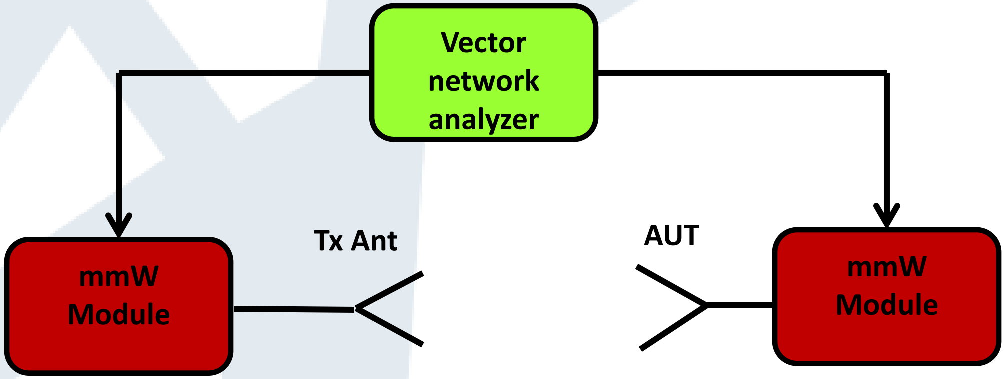
Signal generator + Spectrum analyser

Single frequency, gain/radiation pattern, larger dynamic range


Signal Generator
Mixer
Tx Ant
AUT
Mixer
LNA
Spectrum analyzer

Vector network analyser

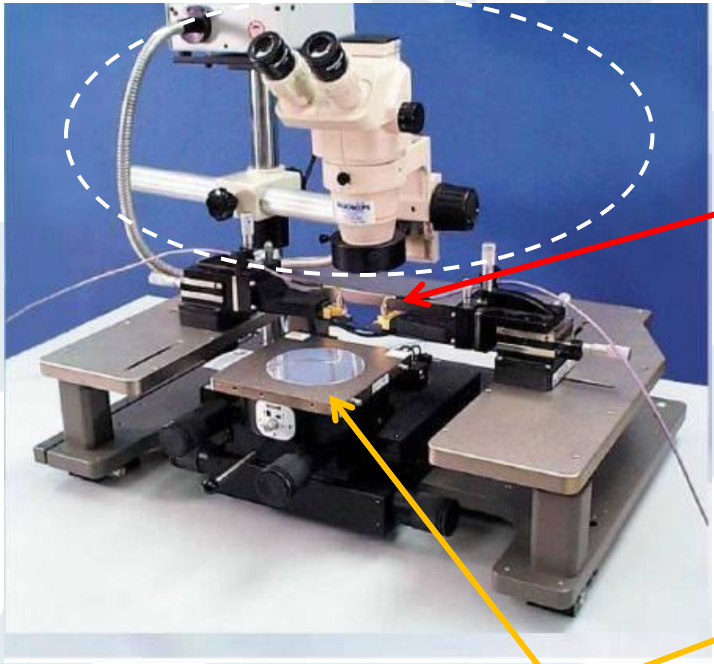
Sweeping frequency, gain/radiation pattern, Impedance matching

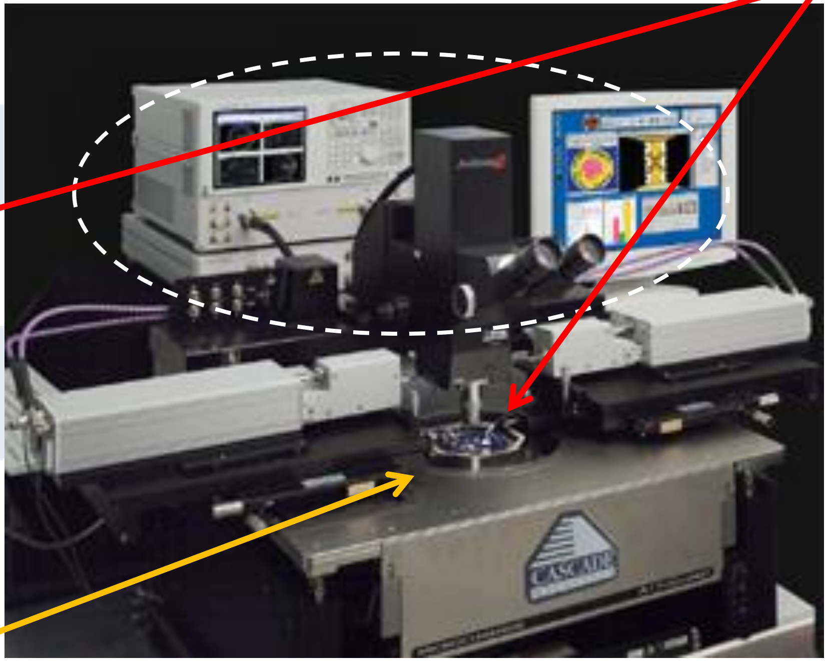

Vector network analyzer
mmW Module
Tx Ant
AUT
mmW Module

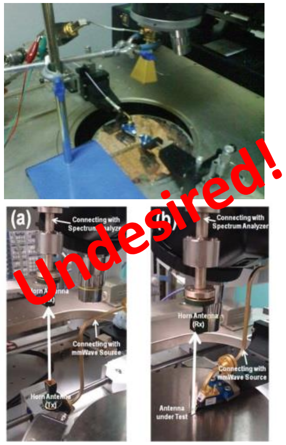
Considerations for system configuration

On-wafer antenna characterization

Infinity Probe
Shows 'B' Waveguide Version
Infinity Probe





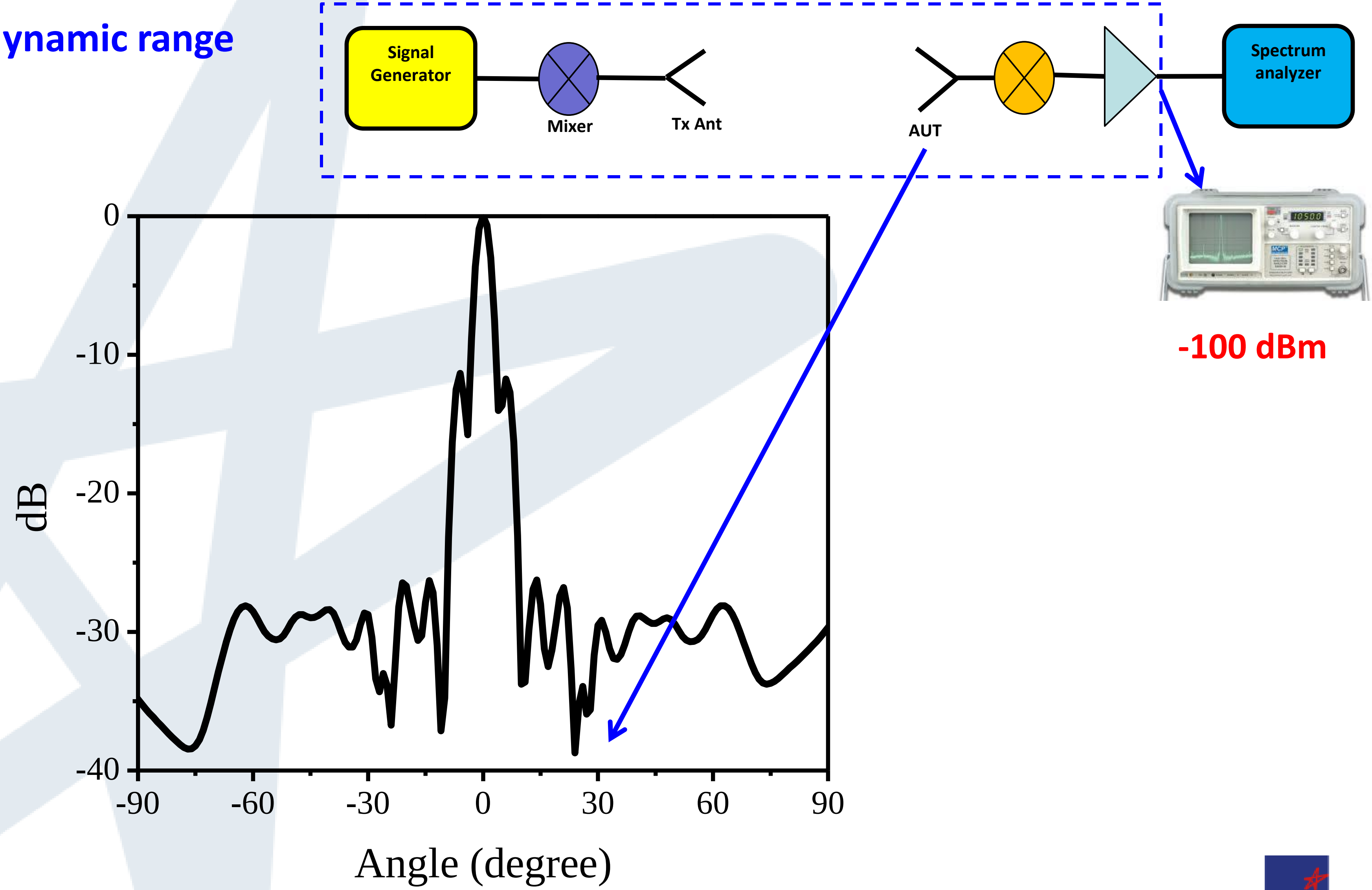

Undesired!
(a)
Connecting with Spectrum Analyzer
Horn Antenna (Rx)
Connecting with mmWave Source
Horn Antenna (Tx)
(b)
Connecting with Spectrum Analyzer
Horn Antenna (Rx)
Connecting with mmWave Source
Antenna under Test

Anti-vibration table

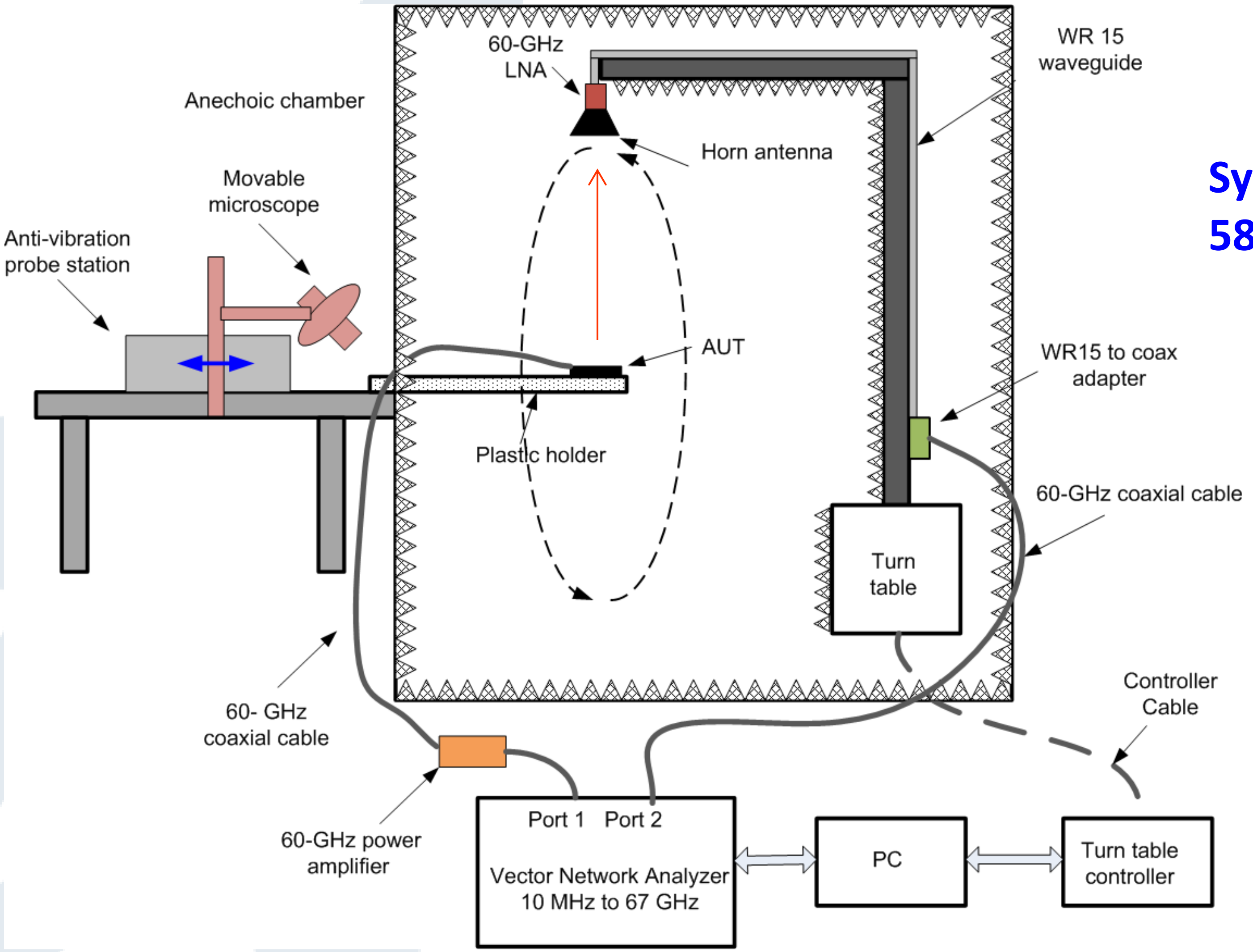
A clear area is desired !

Considerations for System Configuration

System dynamic range

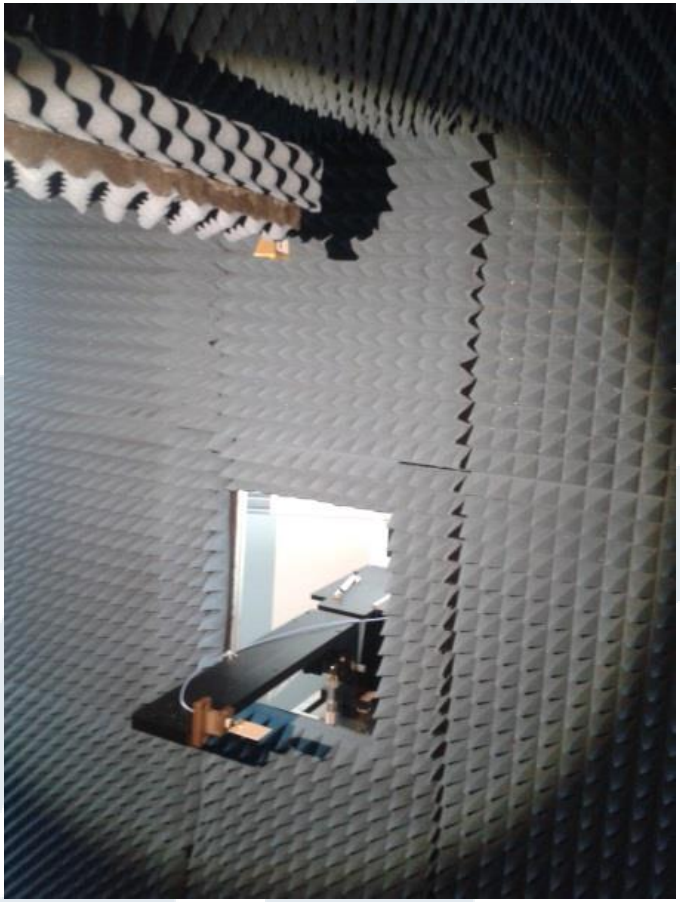

Signal Generator
Mixer
Tx Ant
AUT
Spectrum analyzer
-100 dBm
dB
0
-10
-20
-30
-40
-90
-60
-30
0
30
60
90
Angle (degree)

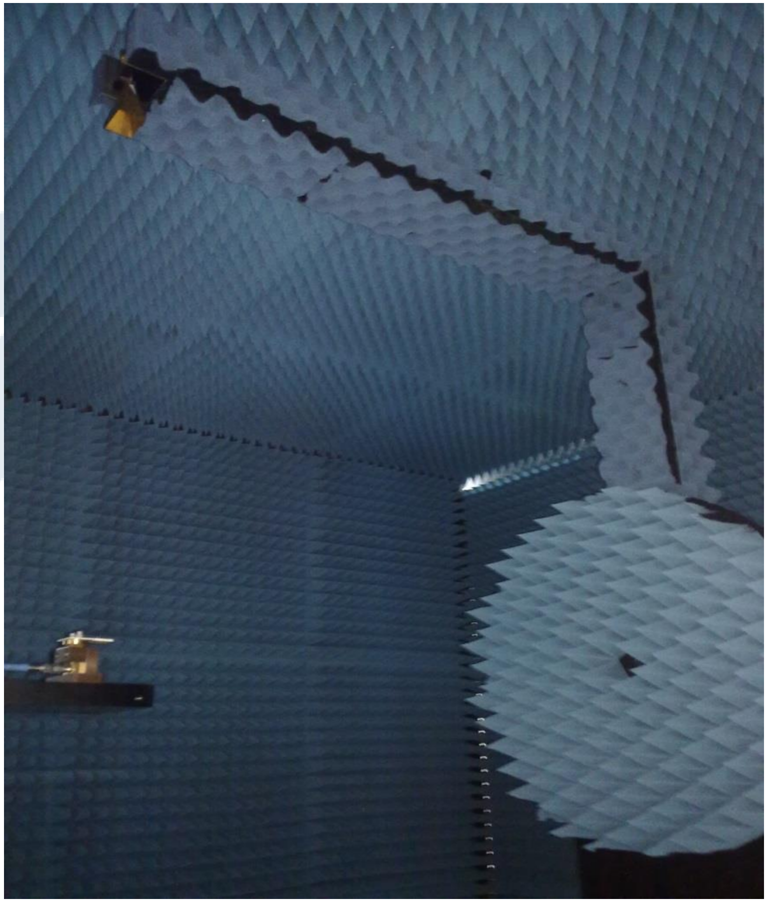
60-GHz antenna measurement set-up (50-67 GHz)


60-GHz
LNA
WR 15
waveguide
Anechoic chamber
Horn antenna
Movable
microscope
Anti-vibration
probe station
AUT
WR15 to coax
adapter
Plastic holder
60-GHz coaxial cable
Turn
table
Controller
Cable
60- GHz
coaxial cable
60-GHz power
amplifier
Port 1
Port 2
Vector Network Analyzer
10 MHz to 67 GHz
PC
Turn table
controller

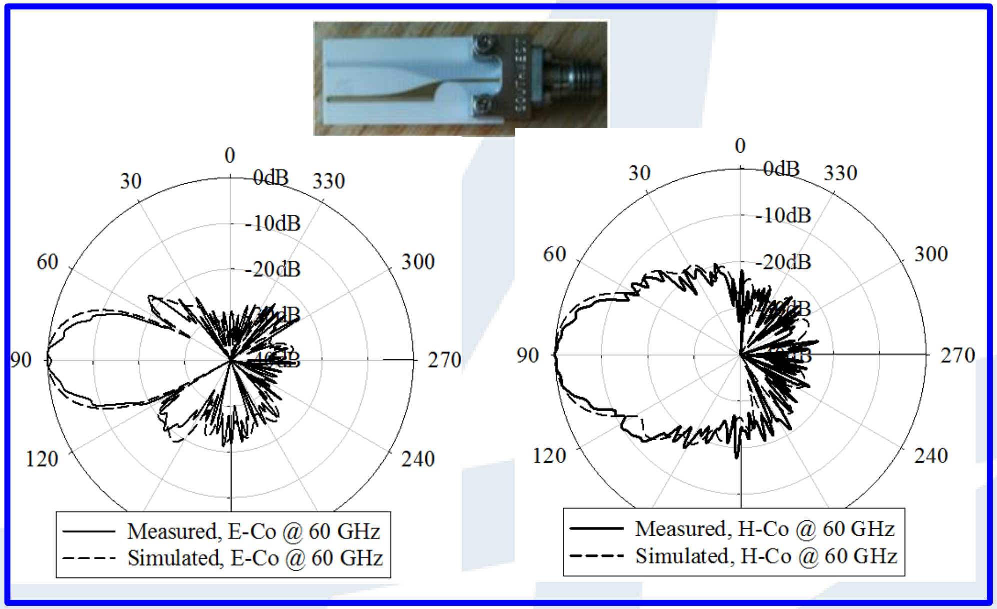
System dynamic range:
58 dB (AUT: 20 dBi)

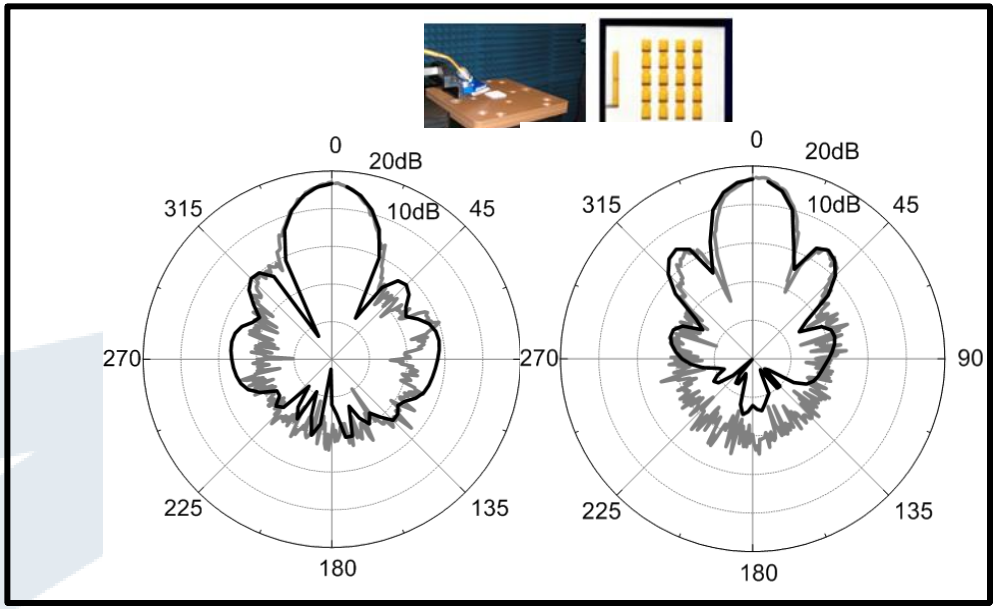
60-GHz antenna measurement set-up

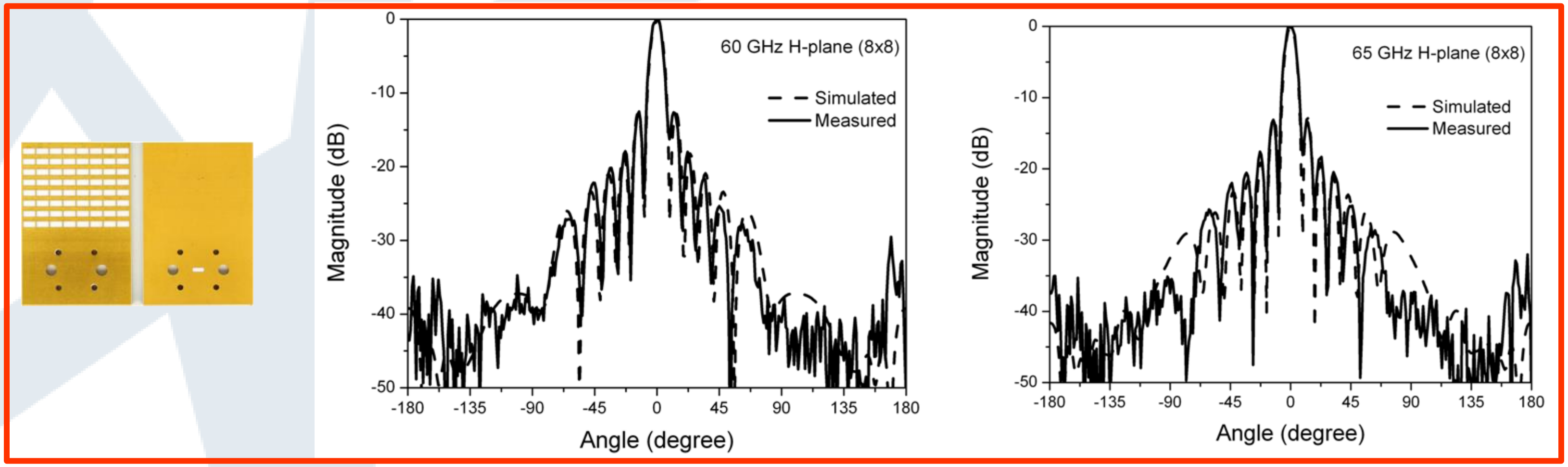


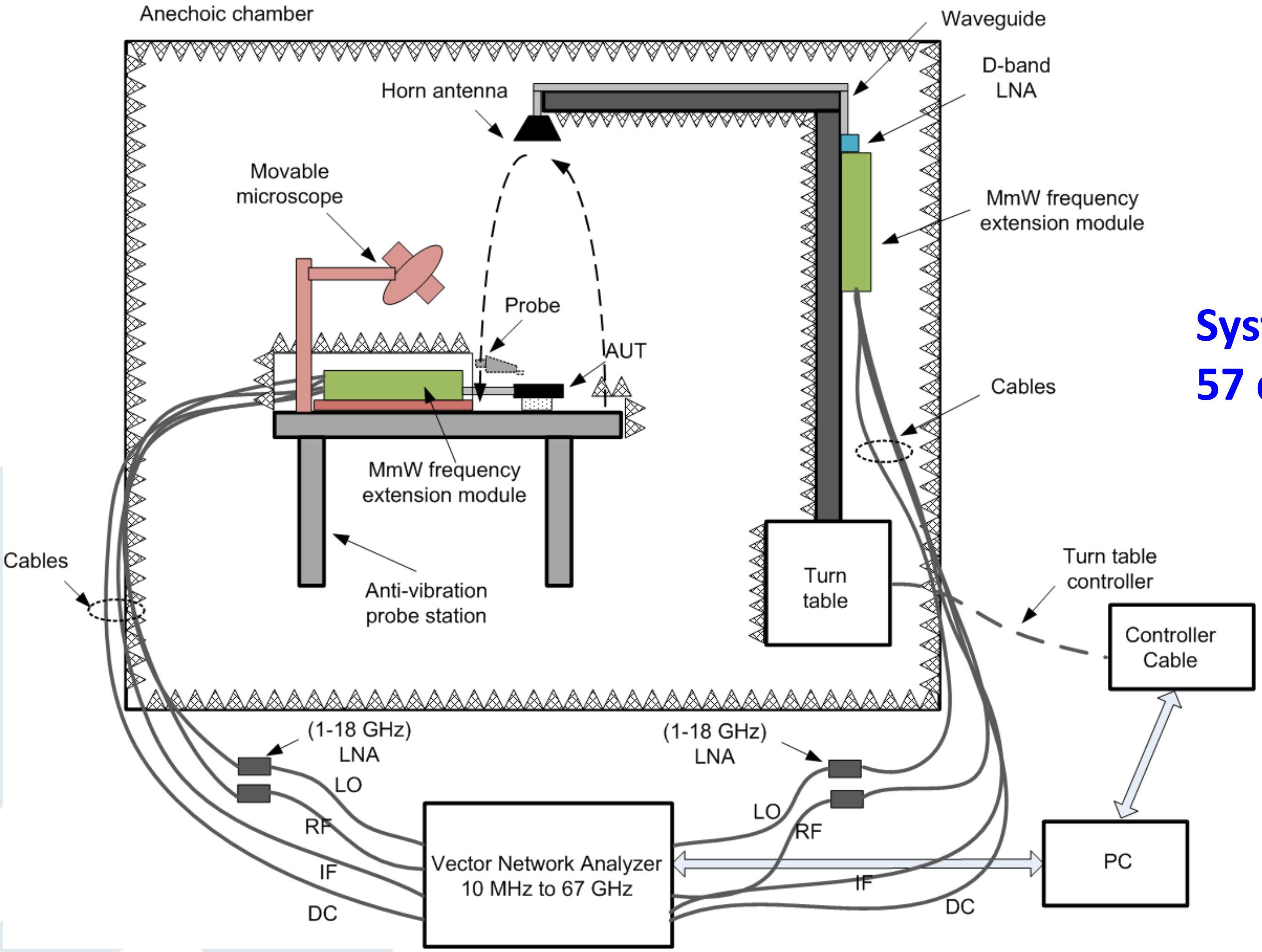


60-GHz antenna measurement examples



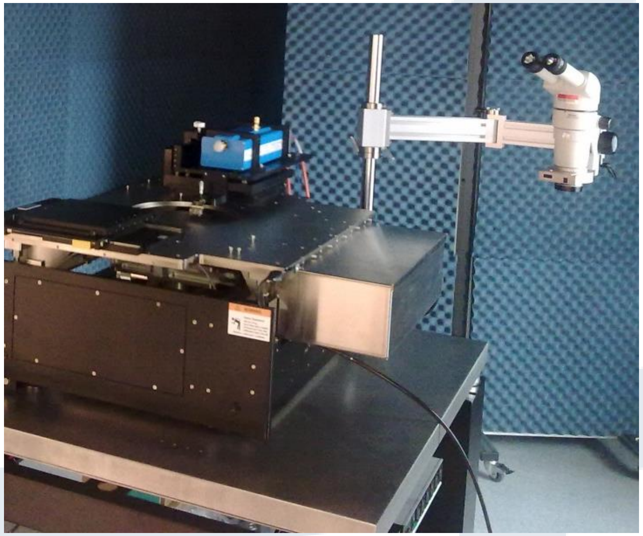


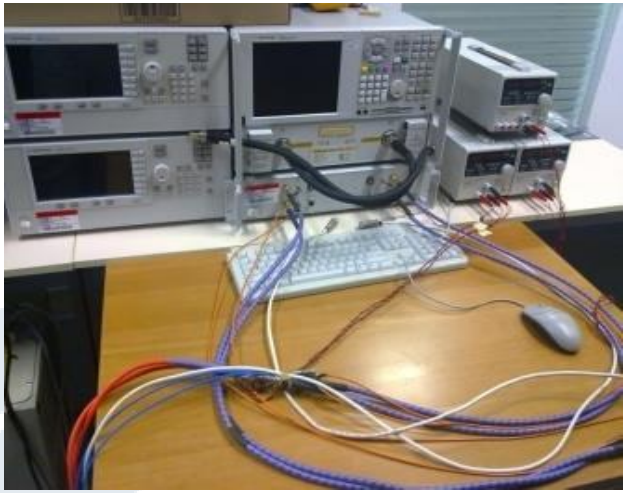


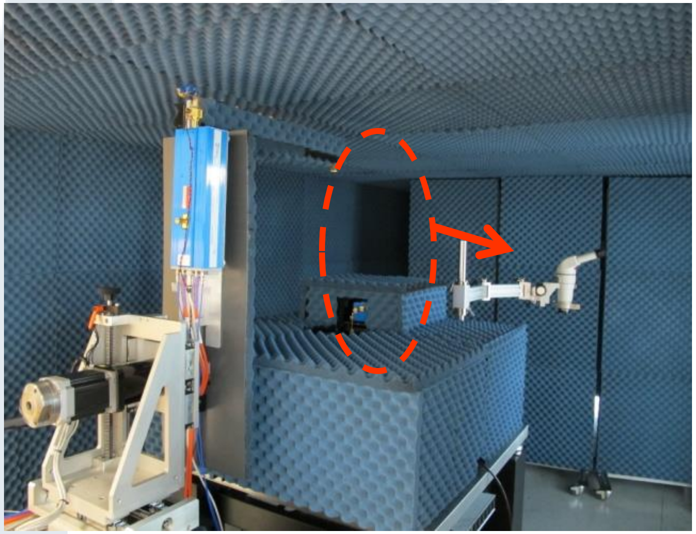

Anechoic chamber
Waveguide
D-band LNA
Horn antenna
Movable microscope
MmW frequency extension module
Probe
AUT
Cables
MmW frequency extension module
Cables
Turn table
Anti-vibration probe station
Turn table controller
Controller Cable
(1-18 GHz) LNA
(1-18 GHz) LNA
LO
RF
IF
DC
LO
RF
IF
DC
Vector Network Analyzer 10 MHz to 67 GHz
PC

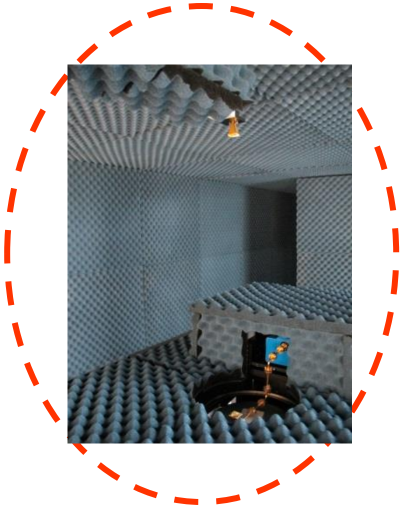
System dynamic range: 57 dB (AUT: 20 dBi)

140-GHz antenna measurement set-up

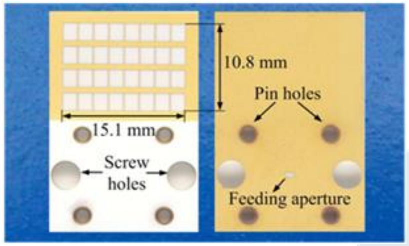


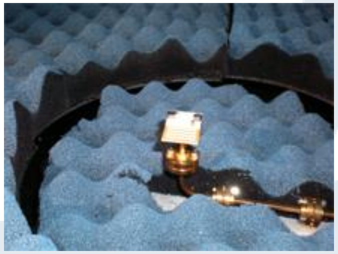


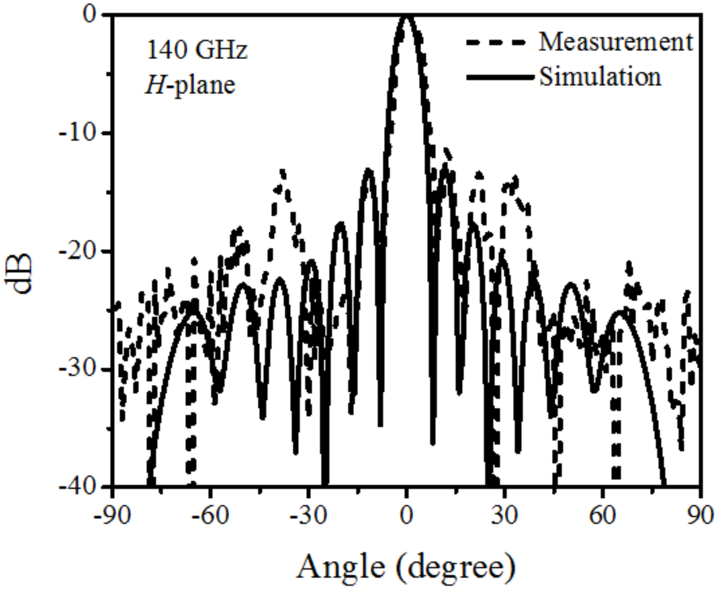


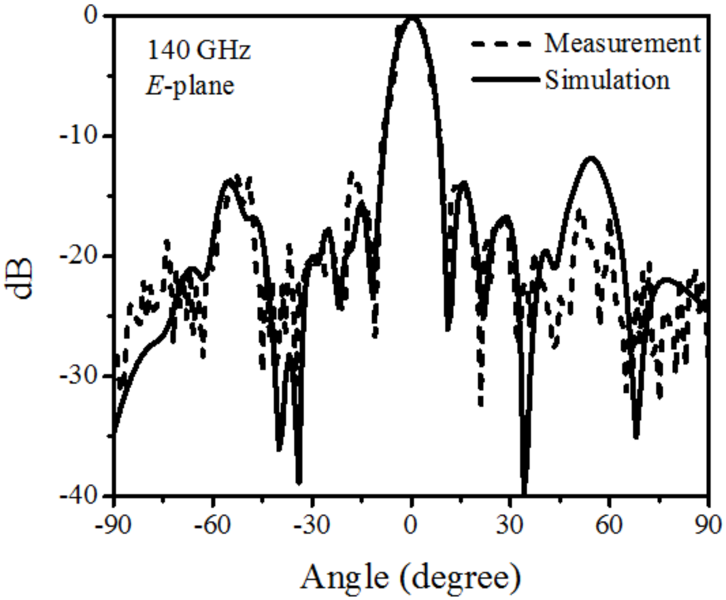


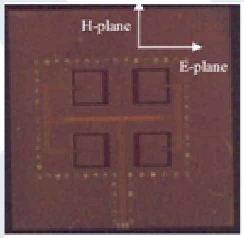
140-GHz antenna measurement examples

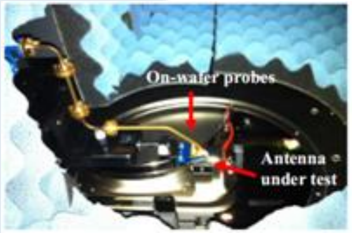

10.8 mm
15.1 mm
Pin holes
Screw holes
Feeding aperture

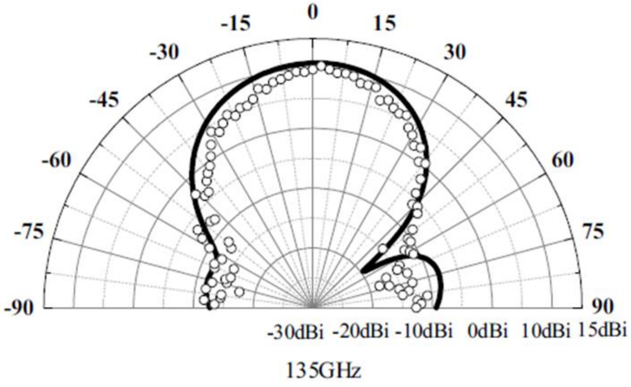




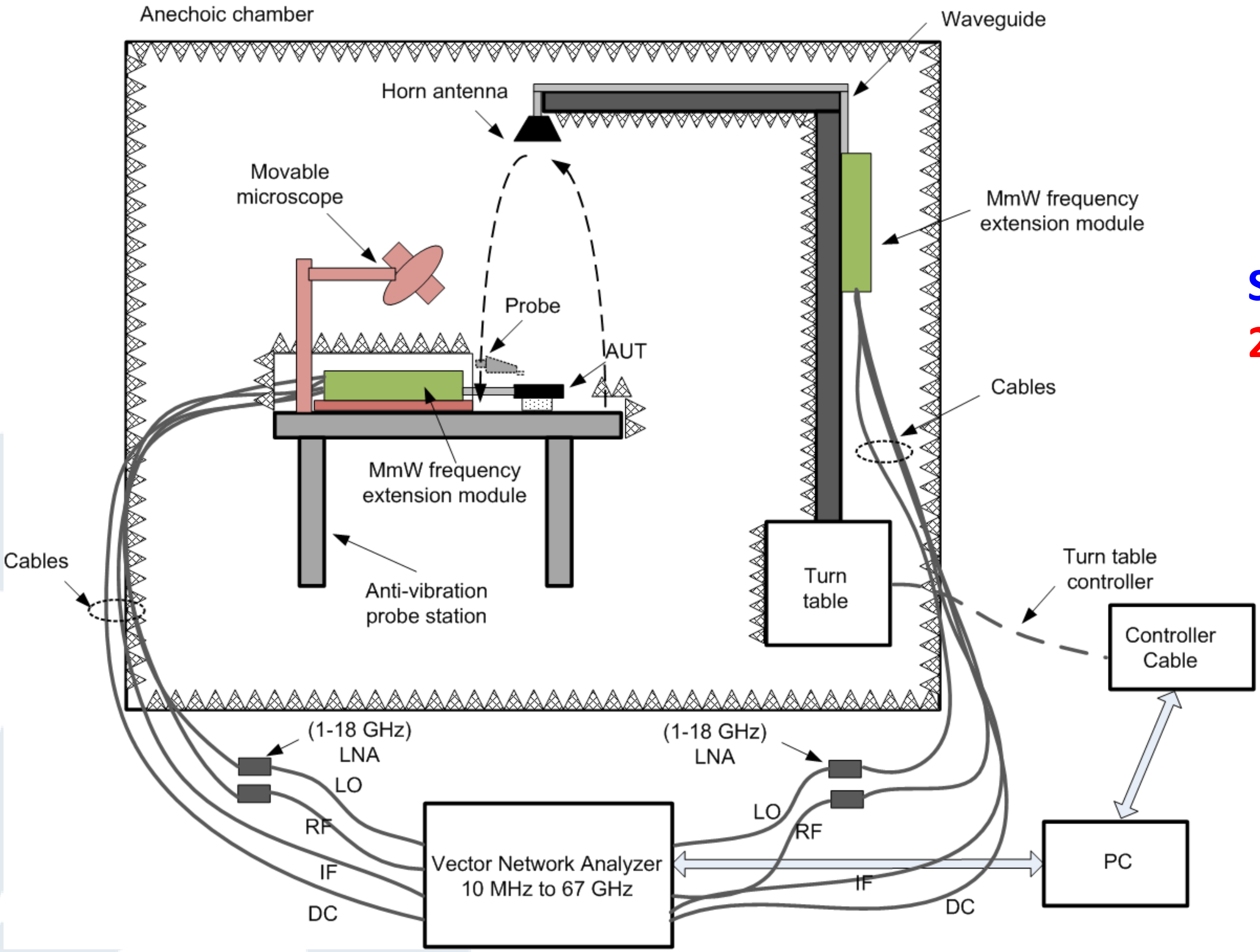



H-plane
E-plane


On-wafer probes
Antenna under test



270-GHz antenna measurement set-up (220-325 GHz)


Anechoic chamber
Waveguide
Horn antenna
Movable microscope
MmW frequency extension module
Probe
AUT
Cables
MmW frequency extension module
Anti-vibration probe station
Cables
Turn table
Turn table controller
Controller Cable
(1-18 GHz) LNA
LO
RF
IF
DC
(1-18 GHz) LNA
LO
RF
IF
DC
Vector Network Analyzer 10 MHz to 67 GHz
PC

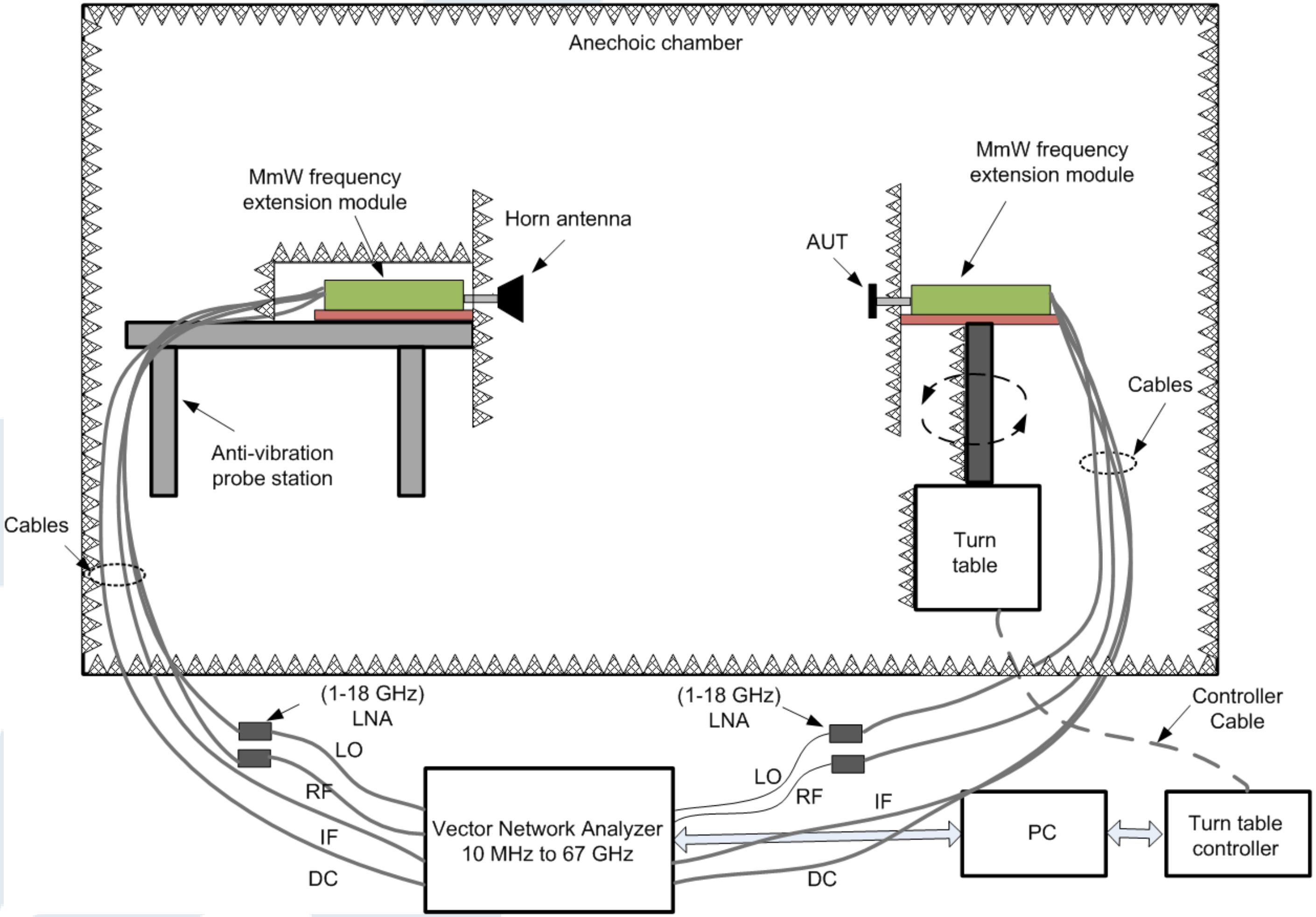
System dynamic range:

2 dB (AUT: 20 dBi)

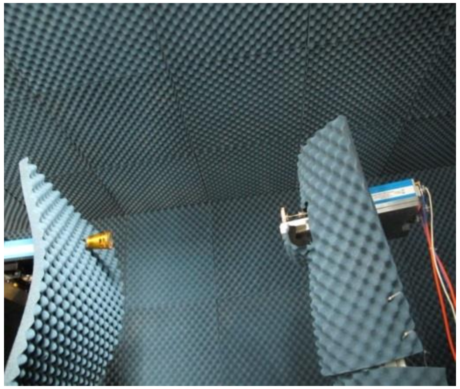
Undesirable!!

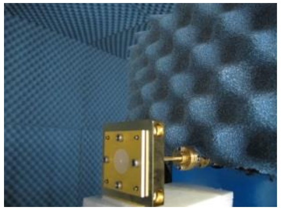
X. Qing and Z. N. Chen

270-GHz antenna measurement set-up (220-325 GHz)

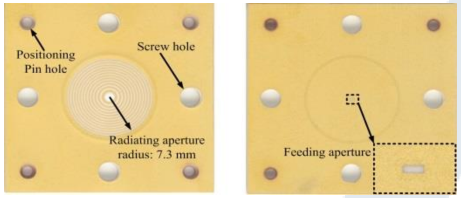

Anechoic chamber
MmW frequency extension module
Horn antenna
AUT
MmW frequency extension module
Cables
Anti-vibration probe station
Turn table
Cables
(1-18 GHz) LNA
LO
RF
IF
DC
(1-18 GHz) LNA
LO
RF
IF
DC
Controller Cable
Vector Network Analyzer 10 MHz to 67 GHz
PC
Turn table controller

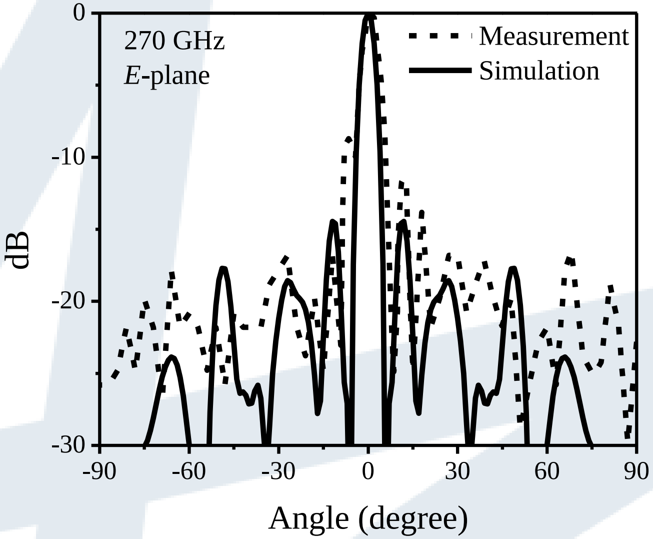
System dynamic range: 23 dB (AUT: 20 dBi)

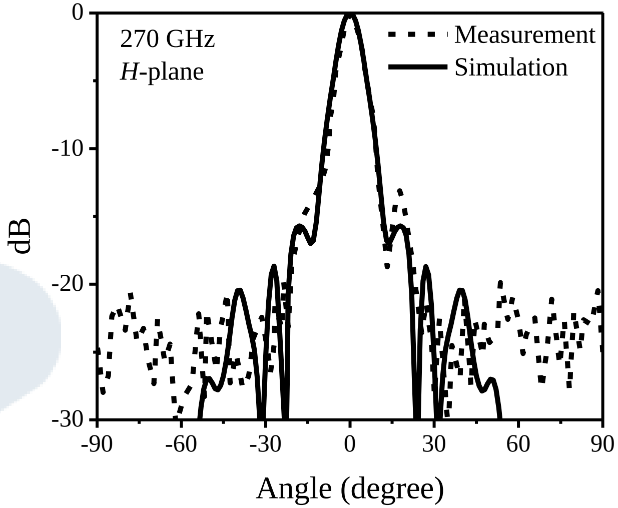


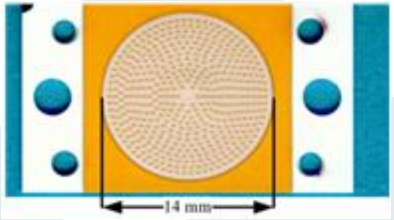


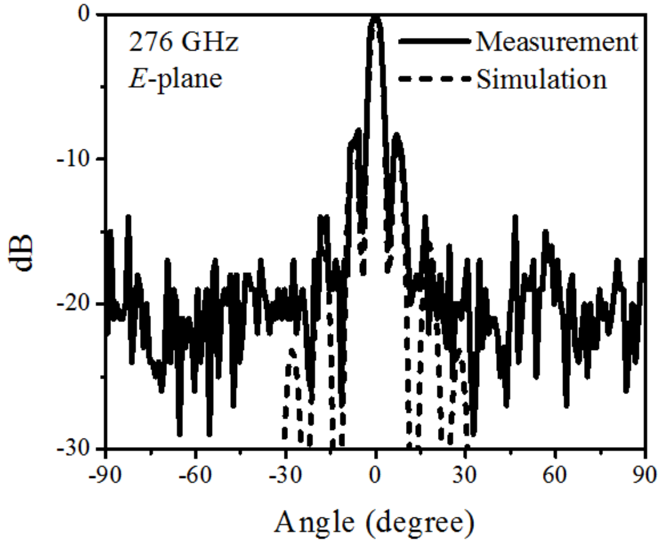
270-GHz antenna measurement examples

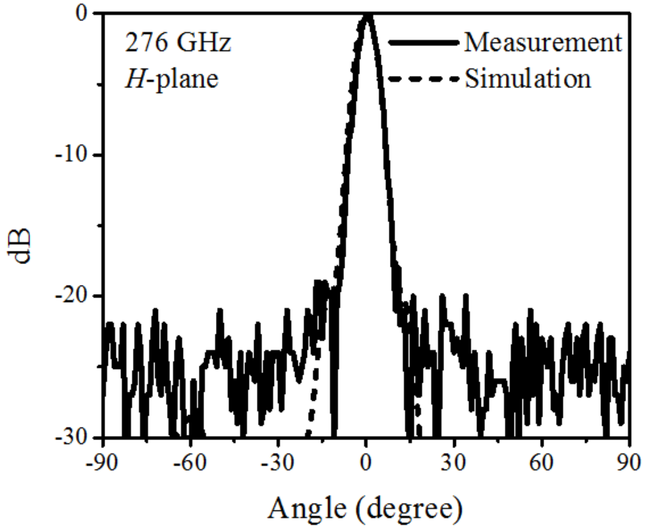

Positioning
Pin hole
Screw hole
Radiating aperture
radius: 7.3 mm
Feeding aperture











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- ➢ Measurement Setups for Millimeter-Wave Antennas
  - ✓ System considerations
  - ✓ 60 GHz system
  - ✓ 140 GHz system
  - ✓ 270 GHz system
- ➢ **Conclusions**

Conclusions

- Antenna measurement at mmW frequencies is a big challenge

  - ✓ Complicated system configuration
  - ✓ Limited system dynamic range, in particular, at upper mmW bands
  - ✓ Expensive configuration

- On-wafer antenna measurement needs extra effort to address

Thanks!

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